Rolls-Royce

Site Visit Report

Ref: SWOF No. 1741

To: Colin Lucas

Date: 20th June 2002

From: Leo Dell

Operator: Newfoundland Power

Site: Greenhill Generating Station. Grand Bank.

Visit Dates From: June 4th 2002 **to:** June 14th 2002

Reason for Visit: Investigate Engine/PT. Vibration problems / Package Inspection

Equipment: Curtiss Wright Generating Set. Olympus Powered. 202203

Personnel Contacted: John Budgell, Maintenance Supervisor.
Glenn Trease, Entronics Dev. Engineer.

1.0 *INTRODUCTION*

1.1 This unit was built by the now defunct Curtiss-Wright company, using a Rolls-Royce " C " rated Olympus engine as the prime mover. The plant was built in the mid-1970s and has been used as a standby generator. The unit has only run approximately 1400 hours since commissioning. The engine has less than 200 hours running time since overhaul in 1999. The operating schedule seems to be a start-up once a month and then run for an hour. The unit had been recently upgraded with a new design of Allen Bradley fuel control and PLC, which still had some outstanding work to be completed.

1.2 The customer had reported high vibration levels for the engine, way above the levels approved by Rolls Royce for correct operation of the engine (correct levels are 17 ½ mm/sec alarm and 19 mm/sec shutdown, the unit runs at anywhere from 24 mm/sec to 30 mm/sec). The customer requested a visit from Rolls Royce to investigate the cause of the high engine vibration levels and also to carry out an inspection of the overall package.

2.0 *CONCLUSIONS*

2.1 The vibration problems have been looked at and a lot of data recorded which show that there is a first order N2 component in the vibration waveform and also a second order N2 component. There is also a 3600 CPM Vibration of 4.5 mm/sec. measured on the engine supports.

2.2 The operation of the power turbine spring boxes and their relationship with the engine alignment is also an unknown, also the engine installation with a nose down attitude with the bellmouth almost in contact with the metal door cutout.

2.3 First order peaks are usually indicative of engine shaft imbalance or shaft alignment problems. Second order point to incorrect installation or problems external to the engine.

2.4 The unit requires a complete review and verification of the Power Turbine installation and alignment, with particular emphasis on the spring boxes, also the engine installation, with the nose down attitude, bearing supports, alignment, etc.

2.5 When all the above checks and verifications have been completed, further vibration data should be taken for analysis.

2.6 The Package condition is poor and from an operational point of view, there may be safety concerns as well, with the amount of corrosion on the structure, walkways, access ladders and the internals of the exhaust stack.

2.7 The vibration monitoring system is an old IRD system and is showing signs of Age, although readings seem to be correct.

3.0 *RECOMMENDATIONS TO CUSTOMER*

3.1 The unit has only run approximately 1400 hours from initial commissioning and the engine at present only completed less than 200 running hours since overhaul, the fact that the engine has been back for overhaul/repair three times since new and tests out fine for vibration on the test bed (10 mm/sec) leads me to believe that our overall problem lies with the installation. I would be very surprised if over the time period in question, that an engine would come back from the overhaul base with the same vibration problem 3 times.

3.2 I would therefore recommend as mentioned in the conclusions, a full review of all the engine and power turbine installation procedures in conjunction with Fern Engineering, in particular the operation of the power turbine spring boxes, the engine nose down attitude, the front engine bellmouth area and verification as much as possible, that the installation is correct.

3.3 There is also the 3600 CPM 4.5 mm/sec vibration component on the engine supports, this may be having an adverse effect on the overall engine vibration and causing the " Cycling Effect " that can be seen on the IRD analyzer, further investigation of this is needed.

3.4 When all of the alignment and verification checks on the installation have been completed a further vibration check should be carried out to establish if any change has taken place in the overall vibration signature.

3.5 Consideration also should be given to replacing the existing vibration monitoring system with a more up to date monitor such as that made by Bently Nevada or Vibrometer , The problem with the installed IRD system is that it is now obsolete and difficult to support and there is some question of just how accurate it is.

3.4.1 PACKAGE INSPECTION./RECCOMMENDATIONS

3.4.2 The Air Intake House needs to be de-rusted/sand blasted, holes repaired in the metal structure, (two hoods have been replaced and are in fair condition), the by-pass door hood is very badly rusted and may need replacement. The by-pass door micro-switch junction boxes are badly corroded and will need replacement. The filter house delta/P alarm and by-pass door functions will need checking for correct operation, all access ladders and walkways showing a lot of corrosion mostly surface, however could be a safety concern, should be sand blasted and checked for integrity and security of attachment, all metal surfaces after treatment /repair should be painted with a good quality primer followed by finish coats.

3.4.3 The Engine Plenum compartment access doors are in fair shape with hinges that look new. The air splitters have some corrosion at the top of the chamber which should be treated and any perforated sheet that is defective should be replaced. A lot of the perforated sheet on the plenum walls is in poor condition and should be replaced along with any insulation underneath. The floor of the plenum is in a bad condition and constitutes a FOD hazard area, with loose drain cover and crumbly concrete. The floor could be treated with a concrete leveling or bitumen compound, to seal it and the drain cover tack welded.

3.4.4 The Engine Compartment is in good condition which I understand was the result of a fire which required a complete re-furbishment of this area.

3.4.5 Power Turbine Compartment is in fair condition some perforated sheet will need replacement, at the floor level and the door needs to be repaired, some priming and painting will be needed.

3.4.6 The Exhaust Stack is in an extremely bad condition, with extensive corrosion externally and internally, there is corrosion of perforated sheet internally and extensive cracking of the steel work inside the stack. There has been an instance where a large piece of perforated sheet has blown out of the stack on to the site, this is definitely a safety hazard. The insulation behind the perforated sheet, inside the stack has fallen to the bottom and will need replacing. The stack will need to be removed section by section and repairs carried out at ground level.

3.4.7 The Base Plate area of the unit also has a lot of rust and corrosion and will need to be treated and painted

4.0 ***WORK PERFORMED, OBSERVATIONS AND TEST RESULTS***

4.1 Arrived at the Greenhill site on June 5th accompanied by John Budgell the maintenance supervisor for Newfoundland Power. We decided to do a walk round inspection of the unit to see if there was any obvious inconsistencies which could contribute to the vibration problems with the engine.

4.2 During the walk round inspection a few potential problem areas were discovered, the first was the power turbine cooling air pipe from the engine delivery casing to the power turbine inlet casing. This is meant to be a flexible pipe but instead we had a solid 4 inch pipe. The next item was the nose down attitude of the engine. This was explained by an instruction from " Fern Engineering " and was to compensate for the "sag " of the power turbine entry duct. There was also the close proximity of the bellmouth to the metal structure of the plenum door, possibly in contact. Then finally the spring boxes at the rear of the power turbine, these two items were as I understand it, in place to compensate for the thermal growth of the power turbine. However they did not seem to be under compression or tension and could be turned by hand.

4.3 A test run was carried out to look at the vibration levels and any other problems, the unit came in to TE control at 14.8Mw and it was observed that there was a discrepancy between the " Actual T6 " and the calculated T6 of approximately 200 degrees Celsius. The unit was shut down to investigate this discrepancy and also to modify the cooling air pipe by inserting a flexible section into the pipe.

4.4 The thermocouple system was checked out by injection, which showed that the thermocouple cabling from the control room to the engine junction box was OK, however it was discovered that all 8 thermocouples were incorrectly aligned with the gas stream, not actually in the gas stream but at 90 degrees to the flow of hot exhaust gas. The thermocouples were correctly installed, along with the modified cooling air pipe. A start was attempted but failed and the unit shut down on Hi Temperature Spread (No. 7), there was also a fault on the PLC which would not clear. The temperature diffential display had also locked up at this time.

4.5 Further investigation was carried out into the thermocouple system, in particular, looking at screens and ground connections for correct installation. All wiring was checked again, nothing was discovered that could cause the problems we were having with starting up. A further attempt was made to start up the unit, this also failed and the unit shut down just as the PT broke away. The same shutdown, High Temperature Spread Differential on No. 7 thermocouple. The same fault on the PLC was still present plus the locked up temperature differential display. The customer had some discussion with Entronics at this point and it was decided to send an engineer to site, to arrive on Monday. We also decided to obtain a boroscope and have a look inside the engine hot section, in particular the area monitored by No. 7 thermocouple.

4.6 The Entronics engineer arrived on site and started to look at some of the fuel control and PLC problems and discovered the following:

4.6.1 Found that in the fuel control program, 4 of the exhaust gas temperature thermocouples were configured as type " J " and the other 4 were configured as type " K ".

4.6.2 Found that some of the individual spread margins were configured differently from each other.

4.6.3 Also found that the spread alarm and shut down plus the T6 control point and shut down, were different from the Rolls Royce standard settings for a "C " rated Olympus. This was explained by the de-rating of the power turbine by Fern Engineering The figures set on site were : spread alarm plus/minus 40 degrees Celsius. Shutdown 50 plus/minus 50 degrees Celsius. T6 control point 720 Degrees Celsius, Shutdown at 737 Degrees Celsius.

4.7 We decided that as the program problems were sorted we should try another start attempt, but before starting we swapped over the No. 6 and No. 7 thermocouple leads at the engine junction box. We shut down again but the fault had transferred to No. 6 high temperature spread differential shutdown.

The No. 7 thermocouple was replaced and the unit was started and ran up to 20Mw. The unit was shut down and a burner was removed to allow access to the area of No. 7 thermocouple with the boroscope. An examination of the area was carried out and nothing unusual was found.

4.8 The unit was now starting correctly and running up to temperature control at around 20Mw. We took a lot of vibration data at various power levels with the customers 2 channel IRD analyzer at different points, including the location of the installed vibration transducer. There is a sort of a cycling effect of vibration levels shown on the analyzer when the unit changes load and it seemed to happen at steady state conditions occasionally as well. The figures recorded by the portable IRD analyzer were comparable with the installed equipment readouts.The unit ran on one occasion at a level of 23.5 mm/sec at full power, the following day at the same power it ran at 18mm/sec. (the Rolls Royce approved settings for this engine are 17.5 mm/sec Alarm and 19mm/sec shutdown.)

4.9 The vibration data taken at the same location as the installed transducer, shows an N2 first and second order peak. We also found a 3600 cpm component with an amplitude of 4.5 mm/sec on the engine support frame.

4.10 A Dial Test Indicator was installed at the rear of the power turbine, alongside one of the spring boxes, to measure the overall movement. Due to thermal expansion, the DTI indicated a movement in excess of one inch from cold to 20Mw, however the effect on the spring boxes was nil.

4.11 All inspections and/or processes described in this report have been carried out in accordance with the following list of reference documents and their amendments:-

5.0 ***ROLLS-ROYCE ACTIONS***

5.1 Evaluate the vibration data and make further recommendations.

Leo Dell
Technical Support Representative
Customer Service Business